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Cover: D. R. Johnson adjusts the flow of gas to the discharge tube of a microwave spectrometer. The products of the microwave discharge in the gas will be reacted with another gas downstream to form unstable molecules. Laboratory detection of these highly transient molecules aids their identification in the interstellar medium by radio astronomers. See page 27.

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

The Institute for Basic Standards

The Institute for Materials Research

The Institute for Applied Technology

Center for Radiation Research

Center for Computer Sciences and Technology

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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LABORATORY WORK AIDS INTERSTELLAR MOLECULE DETECTION

Bureau scientists last year reported the laboratory detection of the $2_{12} \leftarrow 2_{11}$ transition in thioformaldehyde by microwave spectroscopy.¹ In this work, D. R. Johnson and F. X. Powell of the Optical Physics Division successfully generated and characterized the molecule from its gas-phase rotational spectrum. They also suggested that the molecule might be detectable in the interstellar medium. This suggestion was recently confirmed by scientists at the CSIRO Radiophysics Laboratory in Australia, who detected H_2CS in the direction of the galactic center radio source Sgr B2, using the PARKES radio telescope.² The detection in Australia marks the first new molecule to be detected from the southern hemisphere.

Radio telescope studies of the interstellar medium must usually be related to laboratory observations for their interpretation and are, therefore, limited by the availability of reliable laboratory results. Furthermore, the experimental conditions under which these laboratory results can be obtained generally differ very dramatically from the interstellar environment. Frequent collisions with other molecules as well as with the walls of the containing vessel have a pronounced influence on the molecules that can be studied at the relatively high pressures necessary in the laboratory. Many molecules of obvious astronomical interest have not been thoroughly investigated because of problems with their generation and detection under these restrictive laboratory conditions.

Microwave spectroscopy, however, is proving to be a valuable tool not only for detecting but also for

obtaining data on the structure and dipole moments of molecules. Advantages of microwave spectroscopy include the capability of dealing with minute quantities of substances, the measurement process is nondestructive, and the spectrum of several species in the same system can be clearly and unambiguously determined.

The laboratory detection of H_2CS was made with a microwave spectrometer having a parallel-plate absorption cell coupled to a fast-flow



pumping system. The molecule was first observed under continuous-flow conditions by reacting the products of a radio-frequency discharge in methane (CH_4) with carbon disulfide (CS_2), downstream from the discharge zone.

Initial predictions of the thioformaldehyde spectrum were arrived at by assuming a carbon-hydrogen geometry similar to that of formaldehyde with a carbon-sulfur bond extrapolated from other compounds. Observation of the $1_{01} \leftarrow 0_{00}$

transition and its subsequent identification from the Stark effect allowed slight adjustments to the parameters and fairly accurate predictions of a number of other transitions. By observing as few as three of these transitions, it is possible to determine moments of inertia for a molecule. The interstellar observation agreed within 0.03 MHz with the laboratory-observed frequency of 3139.38 MHz.

In addition to the molecules of astronomical interest, other unstable molecules have been detected and characterized at NBS by microwave techniques. Sulfur difluoride, for example, was analyzed and shown to have a C_{2v} symmetry with a bond length of 1.589 angstroms, a bond angle of $98^\circ 16'$, and a dipole moment of 1.05 debye. Other molecules of astronomical or chemical interest investigated recently at NBS include cyanoacetylene, boron monofluoride, and the free radicals BrO and ClO .

The NBS group is also making critical reviews of microwave spectra of selected molecules. These molecule-by-molecule reviews are intended to update and revise the existing tabulated literature for species already identified in the interstellar medium. The best available data from the open literature are being supplemented where necessary with new laboratory measurements to provide a basis for accurately predicting microwave transitions throughout the frequency range accessible to the radio telescopes.

¹ Johnson, D. R., and Powell, F. X., Microwave detection of thioformaldehyde, *Science* **169**, 679-680 (Aug. 1970).

² Sinclair, M. W., Ribes, J. C., Fourikis, N., Brown, R. D., and Godfrey, P. D., Radio detection of interstellar thioformaldehyde, I.A.U. Circular No. 2362 (Nov. 1971).

PRECISION MEASUREMENT OF DENSITY

DEVICE SUITED TO SMALL SPECIMENS

THE NEED FOR COMPARING THE DENSITIES OF SMALL SAMPLES of solids weighing only a few centigrams led the Institute for Materials Research to develop a new method for precision comparison of densities. A. D. Franklin and R. Spal, of the Institute's inorganic materials laboratories, refined the method, which is based on a

technique suggested by Horace Bowman, of the Bureau's metrology laboratories. This method should be useful to any laboratory having to make density comparisons or, with suitable reference standards, making density measurements to precisions within a few parts in 10^4 in very small samples.¹

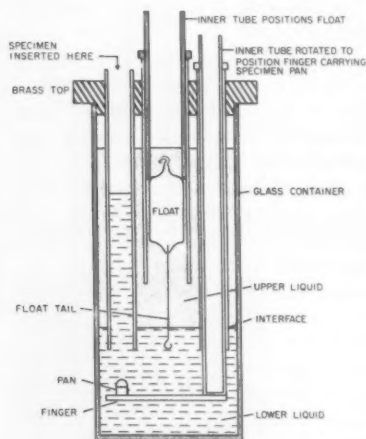
Calcium fluoride (CaF_2) is a crystalline material that has potential as a laser material and, because it is photochromic, to store information optically. The Air Force Materials Laboratory, which sponsors some crystalline material research at the Institute, was interested in the consequences of manipulating defects in the CaF_2 crystals and supported the Institute's work in this area. Some way was needed of identifying the nature of the defects in doped crystals and following changes in concentrations of the defects when the crystals were annealed. Density measurements offered quick and easy assistance in doing this.

At the heart of the density comparator designed by Dr. Franklin is a float having a long, thin wire "tail" extending under it and terminating in a hook to hold the specimen pan.

The float is placed in a vessel containing two immiscible liquids of such densities that the float rides in the upper, less dense liquid with only a little of the wire projecting down to the denser liquid. When a specimen is placed in the pan its buoyed weight can be determined by how much deeper the wire sinks into the lower liquid. The specimen's density relative to that of a standard can be computed from the wire's movement and the specimen's weight in air. The resolution of the method increases as the similarity of the densities of the two liquids increases.

DESIGN OF DEVICE

The float is contained in a glass cylinder fitted with a brass top through which pass three glass tubes on centers forming an equilateral triangle. The float rides in one tube in the upper liquid (benzene with a few percent of heptane added, or water containing a wetting agent), its uppermost and rotational positions being controlled by a snugly fitting inner tube smaller in inside diameter than the float. A second tube extending through the upper liquid into the lower liquid, a fluorinated hydrocar-



This drawing of apparatus for comparing the densities of small specimens shows how the small pan containing a specimen is engaged by the hook at the end of the float's tail. The centers of the three tubes through the brass top are actually equidistant.

bon, permits the specimen and pan to be lowered directly into the lower liquid. A long rod bearing a flat, horizontal finger in the lower liquid can be manipulated from the top of the third tube.

USE OF DEVICE

A specimen is weighed by first lowering the pan containing it through the second tube onto the finger at the bottom of the positioning rod; the rod and finger are then turned until the pan handle can be engaged by the hook at the bottom of the float wire. Then the positioning rod is lowered and the float permitted to seek its equilibrium level.

The length of the wire above the interface of the two liquids is the datum sought. It is measured by use of a cathetometer, or traveling microscopic comparator, focused on an easily identifiable point on the hook at the end of the wire.

Use of the apparatus disclosed that there was some temperature-dependent stratification in the density of the upper liquid and that the difference in volume coefficients of thermal expansion of the float and the benzene caused the float to drift in position. This was partially countered by placing the apparatus in a gently stirred water bath, the temperature of which was held constant to within less than $\pm 0.025^\circ\text{C}$. It was also found that less trouble with drift was encountered when the upper liquid was water, suggesting that the drift was related to the mutual partial solubility of the upper and lower liquids.

The influence of the float's drift was further minimized by repeatedly determining the position of the unknown specimen alternately with members of a series of standard specimens. The drift in position for the unknown was treated as linear and a value interpolated for comparison with one of the standards at the time of its measurement.



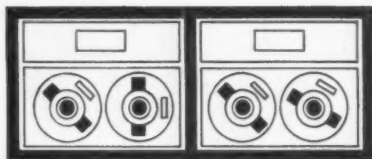
Dr. Alan Franklin lowers a tiny pan containing a specimen of CaF_2 into apparatus developed with R. A. Spal for comparing the densities of small samples. When the pan rests on the finger at the bottom, the finger will be rotated and raised to hook the pan under the float. The buoyed weight of the sample is known from the position of the float's tail in the two immiscible liquids; its density can then be computed, knowing its weight in air and using reference standards.

TEST OF SYSTEM

The density comparator was tested with two groups of crystals, six relatively pure crystals and five doped with 0.45 mole-percent GdF_3 . Positional values were obtained for the pure crystals and the values for the entire group were used in comparison with the positional values

for an unknown, one of the doped crystal specimens or a pure crystal treated as an unknown. Ratios for densities of each unknown and the average value for the standards were determined with a standard deviation of no more than 3 parts in 10^4 .

¹ Franklin, A. D., and Spal, R., A method for the precision comparison of the densities of small specimens, *Rev. Sci. Instr.* **42**, No. 12, (Dec. 1971).



CCST NEWS

This is the inaugural article of a new column about the Center for Computer Sciences and Technology. The column, replacing the series formerly known as FIPS NOTES, will contain items of current interest about the technical activities and accomplishments of the Center and commentaries about significant developments in the computer world which impact on the Federal computer customer. Future articles will cover such areas as software management, performance measurements, the ADP standardization process, teleprocessing and computer networking, computer economics, automation technology, international computer technology, and specific applications of computer technology. This first article is devoted entirely to a summary description of the Center's reoriented technical program and an overview of the computer environment to which the program is responsive.

The Center for Computer Sciences and Technology has, over the last year, undergone an extensive transformation aimed at establishing within the Federal Government a center of excellence to provide scientific and technical leadership in search of more effective ways to exploit the power of the computer. The management of the Center has moved forcefully to insure that the Center is fully responsive to its responsibilities under P.L. 89-306, and to modernize the Center's facilities and build staff competencies to cope effectively with intricacies and complexities of today's computer science and

technology. These actions have been strongly supported by the Director, NBS, the Department of Commerce, the Office of Management and Budget and other Federal agencies including the General Services Administration and the Office of Science and Technology. Reprogramming of FY71 and FY72 resources has effected an immediate refocus of the Center's activities on high-priority national problems in computer utilization; the reoriented technical program for FY73 and succeeding years provides a solid base for an expanded program of research and scientific and technical input to the formulation of far-reaching ADP policies.

TODAY'S COMPUTER WORLD

The computer world of 1971 is significantly more complex than the computer world of 1965 when P.L. 89-306, which resulted in the establishment of the NBS Center for Computer Sciences and Technology, was enacted by Congress. Today's computer technology is a technology of services rather than of goods; the customer's interests in computer hardware and individual programs written for computers are secondary to his interest in the services his computer system provides. Today's computer world is dominated by software and concerns for the computer technological supporting system, i.e., the essential legal, economic, administrative, ethical, and intellectual arrangements through which computer power is made available to customers. In her testimony before the House Subcommittee on Science, Research, and Develop-

ment, Dr. Ruth Davis, Director of CCST, noted that the technological supporting system and software have become the "Achilles Heel" in our attempts to channel the power of computers to serve our best interests.

Computers have become the major technological ingredient of progress in the world today. The pervasiveness of the computer is indicated by the fact that there are currently 63,000 computers in the United States; the supporting labor force of computer operators, programmers, and analysts is currently estimated at 500,000. There are more than 5,300 computers and 69,000 computer personnel in the Federal Government. In addition to Federal, State, and local governments, which account for some 18 percent of total computer usage, computers are diffused broadly through the economy. Some 40 percent of all computer facilities are used in the manufacturing industries; the financial community, including insurance companies, accounts for another 16 percent; the remaining 26 percent is distributed among utilities, wholesale and retail trade, health care facilities, and data processing firms.

Computer technology itself has grown greatly in scope and complexity over the last 6 years. The proliferation of minicomputers and teleprocessing are but two examples of this growth. The growth of the technology coupled with the pervasiveness of computers has created a broad spectrum of complex and interrelated problems that demand urgent attention. In basic terms, there is great need to rectify

a situation in which our ability to produce computer hardware and computer programs has far outstripped our ability to measure and judge their quality. There is a need for an immediate focus of effort on quality control and measurement of computer services and products, on increasing professionalism in the computer field, on intensifying the applications of automation technology, and on decreasing the enormous dissipation of computer skills in unproductive labor.

There is a critical need for improvements in software management including the specific areas of program production, measurement, testing, validation, documentation, control, transferability, legal and proprietary rights of buyer and seller, maintenance and costing. Although the United States is the world's largest producer of computer software, there is virtually no quality control in the computer service industry. The problems of software management are becoming increasingly complex because computer customers are being confronted by a rapidly growing number of alternatives in software products. The urgency of solving the problems of software management is underscored by the fact that initial software costs invariably equal hardware costs for any application and that for a majority of applications initial software costs are estimated to run three to eight times hardware costs.

Our inability to measure the performance of computer services is also a major obstacle to cost-effective utilization of computer power. The basic tools for performance measurement simply don't exist; the computer industry has few meters or gages for measuring either hardware or software performance.

Incompatibilities between computer hardware and software greatly degrade effectiveness and contribute to high costs and waste resources. Finding the remedy for

these incompatibilities is not an easy task; however, solutions can be approached through properly conceived ADP standards which are consensus agreements on how the design, performance, and other characteristics of computer products, processes, services, and systems are to be described and, when possible, measured. A vigorous program of ADP standards development is absolutely essential.

Teleprocessing, as one of the newest and most rapidly growing facets of today's computer world, requires special attention because of its potential as a cost-effective way to share expensive computer resources, i.e., hardware, software, and data banks, and reduce the dissipation of scarce computer skills.

THE CCST TECHNICAL PROGRAM

The reoriented technical program of the Center for Computer Sciences and Technology has been developed against the background of a penetrating analysis of today's computer world which has been described in gross terms in the preceding paragraphs. The program is directed toward the objective of insuring that computer services meet the needs of the customer and that the computer technological supporting system keeps pace with computer technology itself. It is further oriented toward developing and putting into practice the procedures for quality control, operational effectiveness, measurement of performance, and business-acceptable methods of costing the alternative means of computer application and utilization.

The CCST program has been organized around six principal program areas which reflect the more important facets of computer services which can be impacted by computer sciences and technology. The program elements are Computer Utilization, Specific Computer Application, Teleprocessing, Exploratory Development, Scien-

tific and Technological Advisory Services, and Computer Services. A brief description of each of these program elements follows.

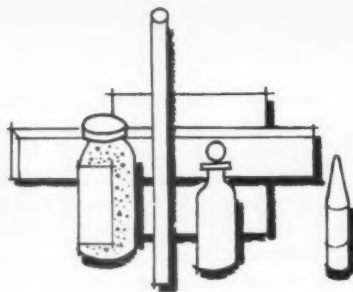
The **COMPUTER UTILIZATION** program is made up of scientific and technical projects aimed at developing the essential techniques, devices, and standards necessary to give the computer customer equity in the marketplace and permit significant dollar savings through improved efficiency and effectiveness of computer utilization. The major technical efforts include: development of techniques and guidelines for measuring the performance of computer hardware configurations and components; development of improved software management techniques; development of standards and performance guidelines for programming languages and input/output devices; development and application of techniques for analyzing the costs of computer services; and improvements in the process of selecting and acquiring computer products and services.

The **TELEPROCESSING** program is aimed at a careful exploration of computer networking technology and the development of cost-effective methods of sharing computer resources through the use of telecommunications to interconnect computers and to connect user terminals to a central computer. The program involves experimentation with time-sharing computer systems and computer networks, including the ARPA (Advanced Research Projects Agency) Network using the Center's currently installed terminal interface message processor (TIP) in conjunction with the CCST-developed dialogue monitor and a PDP-11 minicomputer.

The program in **SPECIFIC COMPUTER APPLICATION** has the objective of insuring that adequate technical support and development

Continued on page 43

STANDARD REFERENCE MATERIALS



Standard Reference Materials are well characterized materials certified for chemical composition or for a particular physical or chemical property. These materials are disseminated by NBS to be used to calibrate and evaluate measuring instruments, methods, and systems or to produce scientific data that can be referred readily to a common base.¹

The NBS Office of Standard Reference Materials announces the availability of 16 new and three renewal Standard Reference Materials. The new SRM's are bilirubin, clinical analysis standard; iron-silicon alloy, microprobe standard; four aluminum on glass and four gold on glass spectral reflectance standards; fused silica, linear thermal expansion standard; three differential thermal analysis standards; two sulfur in fuel oil standards; and high-grade fluor-spar, assay standard. The renewal SRM's are fluor-spar, glass beads for calibrating sieves, and titanium-vanadium alloy for spectrometric analysis.

BILIRUBIN

SRM 916, high-purity bilirubin, is intended for use as a standard for clinical determinations of bilirubin, and for verifying the quality of bilirubin working standards. Bilirubin is a degradation product that results from the normal process of destruction of red blood-cells. It is a toxic material that is insoluble in water and is the pigment seen in patients having jaundice. In excessive levels in a newborn infant, it may

cause permanent brain damage. The mechanism for its elimination from the body involves binding of the bilirubin by serum albumin and transport to the liver, where, by an enzymic process, it is combined with glucuronic acid to form a soluble derivative that is excreted. When the rate of red blood-cell destruction is greatly increased or the elimination pathway is impaired, the concentration of bilirubin in the blood increases. The physician depends on analysis of the patient's blood to determine the total quantity of bilirubin and the relative proportions of conjugated and unconjugated forms.

Bilirubin has been the subject of much research for many years; however, that work has been concentrated mainly in the areas of organic and physiological chemistry. Eight man-years of scientific effort have been expended at NBS in the certification of this bilirubin SRM. Much of this effort has been in the area of development of the analytical techniques necessary for the evaluation of the purity of the bilirubin and the detection of various impurities.

It must be realized that the SRM's issued by the National Bureau of Standards are basically primary standards and will not be able to compete in price with commercially produced control materials. The amount of material supplied (100 mg) is sufficient, however, to perform 8 to 10 primary calibrations and/or to check several lots of commercially produced working (kit) standards. On this basis, the cost per use is not excessive for the

benefits which should result.

This material is provisionally certified at 99.0-percent purity. The principal impurity is occluded chloroform. Also certified are the absorptivities in chloroform and methyl sulfoxide at 453 nanometres. The price is \$92 for a 0.1-gram sample.²

Fe-3Si ALLOY MICROPROBE STANDARD

Fe-3Si alloy microprobe standard, SRM 483, is characterized for chemical homogeneity of iron and silicon at the micrometre level of spatial resolution and is satisfactory for use as a homogeneous material for electron-probe microanalysis. SRM 483 contains by weight percent 3.22 ± 0.02 silicon and $96.7 - 96.8$ iron.

The material is in the form of coarse-grained sheet stock having the so-called Goss orientation in which a (110) grain is parallel to the surface and (001) is the rolling direction. Each sample is supplied HF etched and ready for metallographic mounting and polishing.

Determination of silicon involved 49 samples of SRM 483. SRM 125b, certified at 2.89 weight percent Si, was used as a control standard and 2.90 weight percent Si was found. In the determination, 1-gram samples were dissolved in hydrochloric and nitric acids. A double dehydration of the silicon with perchloric acid was made with an intervening filtration. The weight of silicon present was determined from the loss resulting from treatment with hydrofluoric acid. The price of this SRM is \$50.²

STANDARDS FOR SPECULAR SPECTRAL REFLECTANCE

SRM's 2001, 2002, 2003, and 2004, aluminum on glass, and SRM's 2005, 2006, 2007, and 2008, gold on glass, are intended for calibrating equipment used in evaluating the thermal radiation properties of materials. These SRM's are mirrors prepared by fast vacuum deposition of the metals on fine-annealed borosilicate glass. The surface to be coated was flat to about 27 nanometres. The mirrors are prepared in four sizes as shown in the table below.

Each mirror is certified for near-normal (5°) specular reflectance at wavelengths ranging from 0.2537 to 30 micrometres and at corresponding resolved bandwidths from 1.0 to 1800 nanometres. The price of each SRM is \$275.²

FUSED SILICA

Fused silica, SRM 739, is intended for thermal expansion measurements and calibrations over the temperature range from 80 to 1000 K. It is the second in a series of thermal expansion SRM's to be certified. The complete series will cover the temperature range from 20 to 1900 K. SRM 739, and the previously issued SRM 736, copper, thermal expansion standard, should be of particular interest to laboratories making measurements using relative methods such as push-rod dilatometers.

Laboratories that measure thermal expansion have a definite need for reliable and accurate standards. Experience has shown that it is common for variations among laboratories using push-rod dilatometers to be of the order of a few hundred parts-per-million in $\Delta L/L$.



Thomas Hahn of the Bureau staff makes a thermal expansion measurement on fused silica with a low-temperature interferometer. Standard Reference Materials are useful in making such measurements intercomparable between laboratories.

SRM 739 is available in rod form, 1/4 inch (6.4 mm) in diameter and in 2-, 4-, and 6-inch (51, 102, and 152 mm) lengths, designated as L1, L2, and L3, respectively. The price of L1 is \$71, L2 is \$119, and L3 is \$167.² Inquiries for longer length continuous rods may be directed to the Office of Standard Reference Materials.

NBS-ICTA STANDARD REFERENCE MATERIALS

Differential Thermal Analysis (DTA) Temperature Standards

The NBS Office of Standard Reference Materials, in collaboration with the International Con-

federation for Thermal Analysis (ICTA), has made available three sets of temperature standards for differential thermal analysis (DTA). These Standard Reference Materials comprise a total of eight inorganic substances, which exhibit solid I \rightleftharpoons solid II phase transitions, and two high-purity metals. Three sets of standards that have overlapping temperature ranges (125-435 $^\circ\text{C}$, 295-675 $^\circ\text{C}$, 570-940 $^\circ\text{C}$) are provided. The SRM's are for use in calibrating the temperature scale in the heating mode on differential thermal analysis and related thermoanalytical equipment under operating conditions.

Mean temperature values are based on data obtained by 34 cooperating laboratories in 13 countries employing 28 different types of commercial or custom-made instruments. These values are generally

SRM NO.	SIZE OF BLANK (cm)	COATED AREA (cm)
2001, 2005	7.6 10.2 \times 1.6	5.1 \times 7.6
2002, 2006	3.8 \times 3.8 \times 1.3	2.5 \times 2.5
2003, 2007	disc: 2.9 diameter \times 1.0 thick	entire surface
2004, 2008	disc: 2.4 diameter \times 0.6 thick	entire surface

higher than equilibrium values and vary in a complex manner for different instruments and heating rates. These standards are for use under the specific conditions of the principal experiment: to provide a common basis for relating independently acquired data; and to provide the means for comparing and calibrating instrumentation, regardless of design.

These Standard Reference Materials cost \$45 per set² and comprise the following individual materials shown in the table below.

SULFUR IN FUEL OIL

SRM's 1623 and 1624, sulfur in residual fuel oil, and sulfur in distillate fuel oil, are analytical standards for determining sulfur in fuel oils. The sulfur content of SRM 1623 is 0.268 ± 0.004 by weight percent; for SRM 1624, the sulfur content is 0.211 ± 0.004 weight percent. These SRM's are commercially available oils.

Sulfur was determined gravimetrically as barium sulfate after combustion in a Parr Oxygen Bomb using 1-gram samples, a method similar to ASTM Method D-129. It differs only in that any iron present is removed with ammonium hydroxide before the precipitation of the sulfur as barium sulfate. The uncertainty shown represents the 95-percent confidence limit of the mean based on 12 determinations and allowances for known sources of possible error. These SRM's are each priced at \$30 for a 100-millilitre sample.²

FLUORSPAR

Two fluorspar SRM's, 180 and 79a, are now available from NBS. SRM 180, fluorspar, is a high-grade material certified primarily for the geological and geochemical scientific community. This material contains 98.80 ± 0.03 percent CaF_2 by weight, based on use of a specific method of analysis (given on the certificate). Trace elements were estimated by a general qualitative spectrochemical method with the results given on the certificate for information only. SRM 180 is available in 120-gram units for \$40 per unit.²

SRM 79a, fluorspar, is designed primarily for use as an assay standard for the evaluation of fluorspar imported for industrial use. It is certified to contain 97.39 ± 0.06 percent CaF_2 by weight, based on the U.S. Custom Laboratory Method of Analysis (attached to the certificate). A chemical value for SiO_2 and estimated spectrochemical values for trace elements are included on the certificate for information only. SRM 79a is available in 120-gram units for \$40 per unit.²

CALIBRATED GLASS BEADS

SRM 1017a, calibrated glass beads, is a renewal of SRM 1017 and is intended for use in the evaluation of the effective opening of wire-cloth sieves in the range 100 μm (Test Sieves Nos. 140, 120, 100, 80, 70, 60, and 50). The weight of glass beads in each bottle is about 84 grams. While most of the beads are spherical, about 8 percent by

number range from nearly spherical beads to ellipsoidal beads and a few conglomerates.

Over 60,000 beads were measured in the course of this calibration. These beads were sampled from 24 bottles that were selected at intervals throughout the bottling process. Repeat measurements were made on seven of the bottles. The mean of the standard deviations associated with each diameter is $4.6 \pm 2.0 \mu\text{m}$. This error includes those errors due to the bottling and measuring processes and is to be expected when a given sieve is calibrated with different bottles of this SRM. In addition to this error, the user may impose a sieving error of about $\pm 3.5 \mu\text{m}$, the result of differing ambient conditions. The reproducibility is, of course, dependent upon the sieving method and the care exercised by the operator. SRM 1017a is available in 84-gram units for \$40.²

TITANIUM ALLOY, 6Al-4V

SRM 654a, titanium alloy, 6Al-4V, is a renewal of SRM 654 and is issued for application in x-ray spectrometric analysis. The following elements are certified (weight percent): Al (6.34) and V (3.95). The values for Fe (0.20), Cr (.20), Mn (<.1) and Mo (<.05), are not certified but are given as additional information on the composition. This SRM also may be useful in optical emission spectrometric analysis. Because the standard is thin, in the form of disks 31 mm (1 1/4 in) in diameter and 6.4 mm (1/4 in) thick, bonding it to a more massive backing will permit a greater efficiency in consumption of the material. See ASTM Designation E401-70. This SRM is available for \$35 each.²

¹ For a complete list of SRM's available from NBS, see Catalog of Standard Reference Materials, NBS Spec. Publ. 260 (July 1970 ed.), for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 75 cents; order by SD Catalog No. C13.10-260.

² These SRM's may be purchased from the Office of Standard Reference Materials, Room B314, Chemistry Building, National Bureau of Standards, Washington, D.C. 20234, for the prices indicated.

NBS-ICTA 758 125-435 °C		NBS-ICTA 759 295-675 °C		NBS-ICTA 760 570-940 °C	
Potassium nitrate	10g	Potassium perchlorate	10g	Quartz	3g
Indium	3g	Silver sulfate	3g	Potassium sulfate	10g
Tin	3g	Quartz	3g	Potassium chromate	10g
Potassium perchlorate	10g	Potassium sulfate	10g	Barium carbonate	10g
Silver sulfate	3g	Potassium chromate	10g	Strontium carbonate	10g

DIMENSIONAL

ACCURACY IN MANUFACTURING

The increasing sophistication of modern production machinery has led to better products and higher productivity; it has also led to many problems involving dimensional accuracy. To focus on these metrological problems and techniques for their solution, the Bureau is sponsoring a conference from October 30 to November 1, 1972, at Gaithersburg, Md., with the theme, "Dimensional Accuracy in Manufacturing." Experts in the field of metrology, representing industry, universities, and standards laboratories, will meet to discuss the state-of-the-art and recent advances in metrology pertaining to design and production of machine tools, numerical control systems, gages, precision parts, lasers, and computers.

The Conference will consist of five panel sessions, with presentations by each panelist to be followed by equivalent time for dialogue with the audience. The purpose of the Conference is to help NBS properly orient its measurement research toward the anticipated needs of industry and to acquaint industry representatives with the progress and trends in measurement science. The conference will serve as a forum for open discussion of industrial measurement problems. A tour

of the NBS facilities will conclude the meeting.

The first Session will deal with units of length. Panel chairman Dr. Karl G. Kessler, Chief, NBS Optical Physics Division, will lead a discussion of recent developments in standards of length and the application of new technologies to measurement and gaging.

Session two, Accuracy-Limiting Factors of Machine Systems, will be chaired by Dr. Erwin G. Loewen, Director of Gratings and Metrology Research, Bausch and Lomb, Inc. This Session will cover length transfer, machine motion errors, dynamic and static loading effects, vibration, and assessment of multi-axis machine capability.

The third Session, Thermal Effects on Shop Accuracy, will be chaired by James B. Bryan, Chief Metrologist, University of California, Lawrence Livermore Laboratory. This Session will cover analysis of the problem, methods of control, machine design approach, heat source management, compensation, and types of environments.

The Role of Computers in Improving Machining Accuracy will be the subject of Session four, chaired by Robert E. Esch, Director of Engineering, Automation and Measurement Division, Bendix Corp.

Discussions in this Session will deal with work-piece management, machine error inventory and correction feedback, new approaches to coordinating metrological and production problems, reliability of N/C machines, and the use of statistics in describing machine performance.

The final Session, entitled Conformance Among Measuring Processes, will be chaired by DeWayne B. Sharp, Staff Engineer, Measurement Engineering Dept., IBM Corp. This Session will feature talks on changes in measurement dissemination philosophy and practice, certification of test facilities, traceability, and present and future needs.

The Conference is open to anyone interested in these aspects of metrology; a fee has been tentatively set at \$50. For further information concerning the Conference, to receive an advanced program, or to express a desire to attend, please contact:

A. G. Strang
Room B-164, Building 221
National Bureau of Standards
Washington, D.C. 20234
(301) 921-2126

BOLOVAC EYES INDUSTRIAL MARKET

A new thin-film resistive type of bolometer usable from audio up to millimetre waves needing no rf calibration deserves attention. Termed Bolovac, for *Bolometric voltage and current*, this unique device developed by Myron C. Selby, marks a significant step in measurement technology. When associated with a dc or audio bridge, it performs a simple but highly accurate measurement of voltage, current, or net power from audio to 36 GHz in conventional coax and lumped-constant circuits.

Conceived, developed, and patented (Pat. No. 3487305, issued December 30, 1969) at the NBS Boulder Laboratories, the Bolovac now awaits commercial development and worldwide marketing. In its present form, it can be duplicated by individual laboratories and with some industrial refinements could be made marketable. Numerous inquiries and requests for information received from U.S. and international measurement organizations suggest a unique opportunity for an enterprising instrument manufacturer to supply

Bolovacs to an international market.

The Bolovac is a broad-band voltage-measuring device which utilizes a new approach to microwave instrumentation. The heart of the Bolovac is a thin-film bolometer element having an rf resistance that is the same as that at dc over a frequency range from audio to 36 GHz. Reactance is considered negligible.

Measuring rf power with the Bolovac instead of conventional rf power meters turns a lengthy complex measurement into a short, simple one. Calibration at rf is not required nor do mismatch-correction factors need to be determined. Power is simply measured either in terms of rf voltage or in terms of equivalent dc or af absorbed power.

The Bolovac can also be used to (1) terminate transmission lines for matching or mismatching over an unprecedented range of frequencies and accuracies, (2) measure losses of components, (3) find flaws in its own construction, and (4) calibrate directional couplers.

MECHANICAL FEATURES

Vacuum-depositing the very thin, generally transparent, resistive film in the shape of a washer on a solid insulating disk provides the required mechanical support.

The disk is assembled in a holder that orients the film in a plane normal to, and at the junction of, two coaxial lines. These lines have the same inner and outer diameters as the film washer. The inner rim of the washer makes direct dc contact with the inside conductors of the coaxial lines. The outer rim is isolated from the outer conductors of the lines by capacitors that pass all rf currents above af. The assembly

also permits connecting the film to a dc (or af) bridge that measures the dc film resistance with high precision. Bias power (dc or af) is supplied to the film from the bridge.

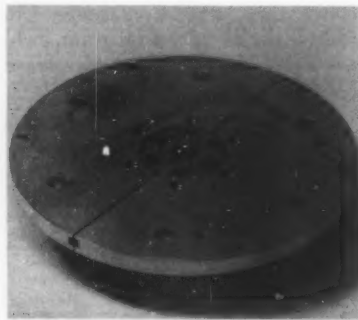
Overall dimensions of the Bolovac for use above 1 GHz are about the same as a flange-type coupler used to interconnect two coaxial lines. Its outer diameter is increased as its frequency range is extended downward. One may connect additional rings to the smallest size (the core of the Bolovac) that will extend the frequency range.

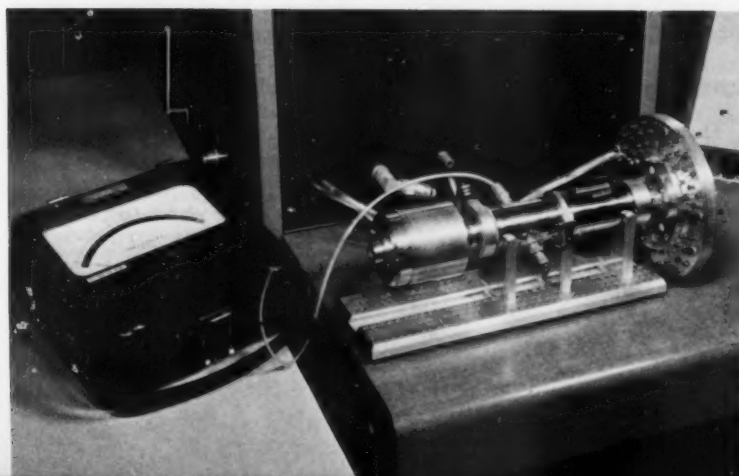
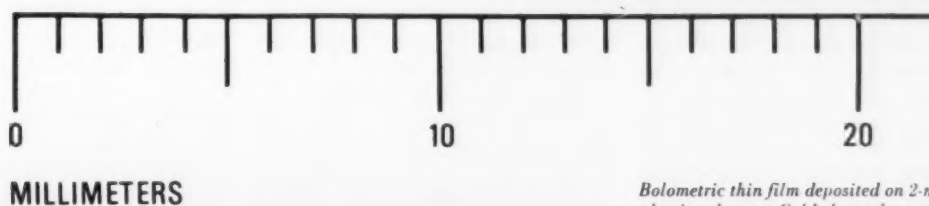
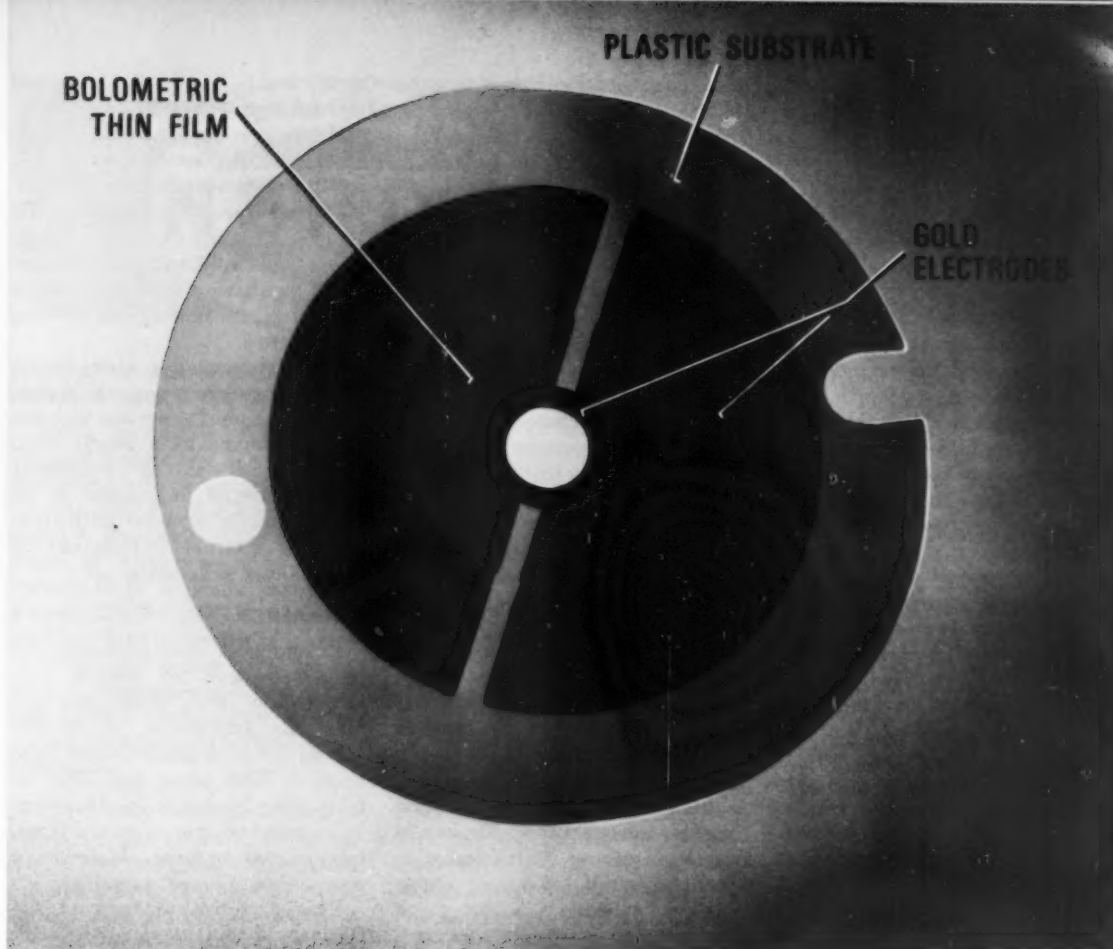
ELECTRICAL CHARACTERISTICS

The Bolovac's principal electrical property is the rf resistance of the film; it is the same at all frequencies as at dc plus having a high temperature coefficient of resistivity. That is, for a given value of rf power dissipated in the film, sinusoidal voltage across the film rf current in the film, and at a fixed bias, the dc bridge measures the same resistance at any frequency in its range.

Bolovac measurements employ the well-known power substitution principle but in a radically different assembly from what is conventionally used. The Bolovac bears very little resemblance to conventional bolometer mounts. The film, its substrate, and the immediate supporting ring form a bolometer. Part of the dc-bias power applied to the film is substituted by rf power in various amounts as desired; the rf power dissipated in the film equals the dc power removed from it necessary to rebalance the bridge. This rf power (and corresponding rf voltage and current) may be computed from the removed bias power. Though these computations are

Interchangeable bolometer cell mounted in center plate of Bolovac. Outer diameters vary in accordance with wavelength of signals to be measured (e.g., 2.5 cm for frequencies above 1 GHz).





Bolometric thin film deposited on 2-mil plastic substrate. Gold electrodes provide electrical contact between film and coaxial conductors. Outer electrode and the resistive film are split into semicircles to permit a dc biasing current to flow through the film from one half of the outer electrode to the other. Radio-frequency currents flow between the inner and outer electrodes; two halves of the film are in parallel. Various thin-film materials may be used to obtain specific electrical properties.

Typical application of Bolovac (far right)—set up to calibrate attenuator-thermoelement voltmeter (ATVM). Large Bolovac diameter permits measurements below 1 MHz.

simple and can be replaced by charts or tables, direct readout electronics can of course be employed for this purpose. Other sensors besides bolometric may be used, e.g., thermoelectric or photoelectric devices; the bridge is then replaced by dc (or af) and photoelectric detectors, respectively.

Film resistance ranging from fractions of an ohm to thousands of ohms can be used. Bolometers safely dissipate about one-fourth watt. Low resistances are desirable when using Bolovacs for low-voltage or for high-current measurements. Resistances equal to characteristic line impedances, such as 50 ohms, are attractive for power measurements. Low-current measurements and negligible power absorption require high resistances.

A unique and useful electrical feature of the Bolovac is that it has two ports (i.e., it has an rf input and rf output end). The Thevenin-equivalent rf impedance looking into its voltage-output end is zero over its frequency range as long as the measured rf voltage is the same.

USES

Presently microwave voltages are very important for (1) system and component performance evaluation, (2) instrument calibration, and (3) studies of properties or materials, field hazards, plasmas, etc. The Bolovac is by far superior to the present power-impedance method to produce or measure known voltages and currents. In many instances it reduces the measurement time from hours to minutes, increases accuracies of results several fold, eliminates rf-calibration requirements, and reduces considerably technical competence required of personnel.

The Bolovac is capable of measuring voltages directly at the input planes of voltmeters, oscilloscopes, spectrum analyzers, field-strength meters, etc. for calibration, frequency-response study, fast-pulse-reproduction evaluation, voltage-breakdown observations and

other purposes. Feeding rf into the Bolovac in series with a coaxial resistor at its voltage-output end forms a nearly ideal signal generator for some of these measurements.

Power can be measured by employing the Bolovac either as a feed-through or as a power-absorbing device. Net power outputs of signal generators and other sources are measured under various matching conditions. A major source of difficulty and error encountered with conventional techniques is the mismatch uncertainty. Other sources of trouble include the need to measure impedances, make complex computations, and sustain successive calibrations in three or more laboratories, a process which reduces accuracies exponentially. The Bolovac largely eliminates these sources of error. Power meters and directional couplers are calibrated directly in terms of net power flow equal to a substituted dc (or af) bias power.

Current meters and sensors such as thermoelements can, for the first time, be conveniently calibrated at frequencies above 1 GHz. Insertion loss (attenuation) of tuning stubs, couplers, transmission lines, and other components can be measured with the Bolovac. Because the film resistance is known and remains constant at all frequencies, the Bolovac serves as an ideal rf termination for power, impedance, attenuation, slotted-line evaluation and other applications. Finally, because a given Bolovac can be operated two ways—as a voltage source and as a power sink—it can self-check and expose its own possible defects.

SUPERIORITY

The advantages over conventional approaches for computing microwave voltages and currents from power and impedance measurements include (1) considerable time saving, (2) reduced requirements in personnel competence, (3) far less expensive measuring instru-

ments and laboratory facilities, and (4) improved accuracy.

All present-day power meters, including directional-coupler types, require calibration in terms of standardized national calorimeters. The Bolovac depends on dc or af standards found in essentially all laboratories and having accuracies one or two orders of magnitude higher than rf standards.

When connected in series with a known impedance (e.g., a 50-ohm resistance), an rf generator with the Bolovac serves as a nearly ideal signal generator of accurately known internal impedance at all frequencies; it is rather difficult to measure internal impedances of conventional generators.

AVAILABILITY

Laboratories may reproduce for immediate use the models constructed at NBS. While procurement or fabrication of 50-ohm bolometers is desirable, there have been at NBS some difficulties in fabricating 50-ohm units. However, up-to-date information on the feasibility of making these (obtained in a recent survey) is very promising.

The attractive features of the Bolovac should render it an indispensable new measuring instrument and a useful addition to the conventional power meters on the market. Industrial refinements, quantity production, adaptation of existing bridges and design of direct-readout circuits should yield a competitive instrument of wide demand and a lucrative market.

For further details, see:

¹ Selby, M. C., Voltage measurements at high and microwave frequencies in coaxial systems, *Proc. IEEE* **55**, No. 6, 877-882 (June 1967).

² The Bolovac, *Nat. Bur. Stand. (U.S.)*, *Tech. News Bull.* **51**, No. 12, 270-271 (1967).

³ Selby, M. C., Bolometric voltage and current (BOLOVAC) standard for high and microwave frequencies, *J. Res. Nat. Bur. Stand. (U.S.)*, **72C** (Eng. and Instr.), No. 1, 61-79 (Jan.-Mar. 1968).

⁴ Selby, M. C., Bolovac applications for H.F. and microwave power measurements and standardization, *J. Res. Nat. Bur. Stand. (U.S.)*, **74C** (Eng. and Instr.), No's. 3 and 4, 123-133 (July-Dec. 1970).

⁵ Selby, M. C., The Bolovac and its applications, *IEEE Trans. Instrum. Meas.* **IM-19**, No. 4, 324-331 (Nov. 1970).

⁶ Selby, M. C., Bolovac systems for measuring electrical quantities from 0.5 MHz through microwaves, *NBS Monograph* 123 (in press).



NEWS

SELECTED VALUES OF CHEMICAL THERMODYNAMIC PROPERTIES

NBS Technical Note 270-6, *Selected Values of Chemical Thermodynamic Properties, Tables for the Alkaline Earth Elements (Elements 92 through 97 in the Standard Order of Arrangement)* by V. B. Parker, D. D. Wagman, and W. H. Evans¹ (\$1.25, SD Catalog No. C13.46:270-6) is the 6th in a series of Notes containing tables of numerical values prepared as a revision of NBS Circular 500, *Selected Values of Chemical Thermodynamic Properties*.

This Note contains tables of values for the standard heats and Gibbs free energies of formation, entropies and enthalpies at 298.15 K, and heats of formation at 0 K for compounds of beryllium, magnesium, calcium, strontium, barium, and radium.

All values in these tables have been calculated from data in original articles using consistent values for all subsidiary and auxiliary quantities. The original data were corrected where possible for differences in energy units, molecular weights, temperature scales, etc., to maintain a uniform scale of energies for the substances in the tables. Further, the tabulated values of the properties of a substance satisfy all the known physical and thermodynamic relationships among these properties, as for example, the quantities ΔH° , ΔG° , and S° at 298.15 K satisfy the relation: $\Delta G^\circ = \Delta H^\circ - T \Delta S^\circ$. Technical Note 270-6 contains an index of the contents of the other Technical Notes in the series.

As additional revised tables of Circular 500 are completed they will be published in the Technical Note 270 series. Because of the urgent need for the data, all tables after revision will be combined with a description of the evaluation process and a listing of data sources into a single publication that will be part of the NSRDS series of critically evaluated compilations.

A GUIDE TO PROCEDURES FOR THE PUBLICATION OF THERMODYNAMIC DATA

Under the auspices of the International Union of Pure and Applied Chemistry's (IUPAC) Commission on Thermodynamics and Thermochemistry, *A Guide to Procedures for the Publication of Thermodynamic Data* has been issued. This Guide was previously ratified by the All-Union Calorimetry Conference of the U.S.S.R., the Calorimetry Conference of the United States, the Experimental Thermodynamics Conference of the United Kingdom, the Society of Calorimetry and Thermal Analysis of Japan, and the Société Française des Termiciens of France.

In 1953 the 8th U.S. Calorimetry Conference adopted a resolution providing guidance on minimum publication standards in calorimetry. This resolution aided and resulted in an improvement in the quality of publication, and so led the Calorimetry Conference in 1960 to revise, extend, and publish its recommendations. A second revision was authorized in 1970. The present Guide is the result. The IUPAC Commission on Ther-

modynamics and Thermochemistry urges all who publish thermodynamic data to follow the suggestions of the Guide. Journal editors and referees are also advised that the Guide embodies a set of consistent, carefully considered criteria for judging the completeness and acceptability of papers reporting thermodynamic quantities. Taken into consideration by the Guide are the needs of the compiler and correlator of data.

Although the Guide is too long to be published in full in the NSRDS NEWS the following quotation provides a good background of its concerns:

ESSENTIAL INFORMATION

"The highly interdependent nature of thermodynamic data imposes special obligations upon the author of papers reporting the results of thermodynamic investigation. He must give enough information about his experiment to allow readers to appraise the precision and accuracy of his results so they may be properly consolidated within the existing body of data in the literature. Further, as accepted values of physical constants change or as new thermodynamic data for related systems become available, subsequent investigators often can recalculate results if it is clear that they are based on good experiments for which adequate information is presented, however old they may be. For these reasons, an author's prime responsibility is to report his results in a form related as closely to experimentally observed quantities as is practical, with enough experimental details and auxiliary in-

formation to characterize the results adequately and to allow critical assessment of the accuracy claimed. For the convenience of the reader, the author may interpret and correlate the primary results as appropriate and present derived results in a form easy to utilize. However, such derived (or secondary) results *never* should be published at the cost of omitting the primary results on which they are based. Reference may be made to accessible earlier publications for some details.

"In addition to the presentation of the data themselves, estimates of the precision indices and probable accuracy of the data should be given by the authors. The various sources of uncertainty should be rigorously described with clear separation of measurement imprecisions, numerical analysis deviations and possible systematic biases. The methods and assumptions for the statistical analyses should be indicated. Possible sources and magnitudes of systematic errors should be identified and enumerated.

"Because temperature scales are of such great significance for all thermodynamic measurements, the considerations and conversions cited by Rossini² and others should be observed. For accurately measured temperatures depending on an International Practical Temperature Scale, the scale used in calibration of the temperature-measuring instrument(s) (e.g., 'IPTS-48 as amended in 1960') and the scale to which the specified temperature values refer (sometimes these two scales are different, e.g. the latter might be IPTS-68) should be stated, stated.

"In instances where requisite primary results are too extensive or for other reasons do not merit journal publication in full, the use of auxiliary publication services may be appropriate.³ A footnote in the publication indicates how the reader may obtain the adjuvant data . . ."

The major sectional headings that follow should give the reader an indication of the full contents of the Guide:

1. Apparatus and Procedures
2. Materials
3. Symbols, Terminology, Units
4. Mode of Presentation of Results
5. Presentation of Thermochemical Calorimetric Data
6. Presentation of Thermophysical Calorimetric Data
7. Presentation of Calculated Thermophysical Functions
8. Presentation of P, V, T Data
9. Presentation of Other Equilibrium Measurements
10. Nondefinitive Data

The full text of the Guide is scheduled to be issued in several publications. The English text will appear in *Pure and Applied Chemistry* and in *The Journal of Chemical Thermodynamics*. The Guide also will be translated into French, German, Japanese, and Russian for publication in appropriate journals. English text copies of the Guide may be obtained from Prof. Edgar F. Westrum, Jr., Department of Chemistry, University of Michigan, Ann Arbor, Mich. 48104. Professor Westrum also would be interested in receiving comments for subsequent revisions.

CUMULATIVE INDEX TO PAPERS ON RADIATION CHEMISTRY

The Radiation Chemistry Data Center, Notre Dame University, associated with NSRDS, as part of its operations, collects, keywords, and stores literature of fundamental radiation chemistry and related fields. Since 1968, references to this literature have been stored in computer files for use in retrospective searches and for the *Weekly List of Papers on Radiation Chemistry* which the Center publishes as a current-awareness aid to radiation chemists. The Radiation Chemistry Laboratory, University of Notre Dame, beginning with the period January through June 1971 will publish semi-annually an index to

and cumulation of entries appearing in its *Weekly List of Papers on Radiation Chemistry*. The first issue has been published by the Office of Standard Reference Data, National Bureau of Standards, for the Radiation Chemistry Data Center and is being made available through the National Technical Information Service. The references within the first issue have been obtained from scanning appropriately 40 current journals as well as Chemical Abstracts and Nuclear Science Abstracts. References are grouped into the following broad categories:

1. Radiation Chemistry
2. Polymers
3. Biological Systems
4. Hot Atom Chemistry
5. ESR
6. Luminescence
7. Photochemistry
8. Theoretical
9. Miscellaneous

Within each category, arrangement is by accession number assigned serially. There is also a keyword listing with publications bearing on the keywords indicated.

This Cumulative Index may be ordered from the National Technical Information Service, Springfield, Va. 22151 for the price of \$6.

OMNITAB II, USER'S REFERENCE MANUAL

NBS Technical Note 552, *OMNITAB II, User's Reference Manual* by David Hogben, Sally T. Peavy, and Ruth N. Varner¹ (\$2, SD Stock No. 0303-0918) has been designed to make computing easy, accurate, and effective, particularly for persons who are not programmers. OMNITAB II is a general-purpose program, which can be learned quickly, for both simple and complex numerical, statistical, and data analysis. OMNITAB executes instructions written in the form of simple English sentences. Problem-solving is further enhanced by the natural structure of the system and its many features. OMNITAB has been used successfully in govern-

ment, industry, and universities across the country and in several centers abroad. The system has been implemented on large computers of at least seven different manufacturers.

The original version of OMNITAB has been completely rewritten to make it as machine-independent as possible and to implement many improvements. Technical Note 552 presents details enabling the user to find specific information in any particular instance. PART A is a simple, compact introduction to OMNITAB for people who have had no experience using a large computer. PART B describes the general and special

features of the OMNITAB system. PART C gives explanations, with short examples, for the use of specific instructions. PART D is a complete alphabetical list of the instructions in the system.

TRANSLATION OF VISCOSITY OF GASES AND GAS MIXTURES

Viscosity of Gases and Gas Mixtures, A Handbook by I. F. Golubev¹ (\$3, TT 70-50022) is a reference handbook in a series of Russian translations being published by the Department of the Interior and the National Science Foundation. This book describes methods and instruments for determining the viscosity of gases under very different experi-

mental conditions. Experimental data for almost all the gases studied are given in generalized tables and graphs suitable for practical use. Data are given on the viscosity of gas mixtures, especially at higher pressures. The book also gives equations and methods for calculating the coefficient of viscosity.

¹ Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 for the price indicated.

² Rossini, F. D., *J. Chem. Thermodynamics* **2**, 447 (1970).

³ For example, National Auxiliary Publications Service of the American Society for Information Science, c/o CCM Information Corp. 909 3rd Ave., New York, N.Y. 10022.

⁴ Order by number from the National Technical Information Service, Springfield, Va. 22151 for the price indicated.

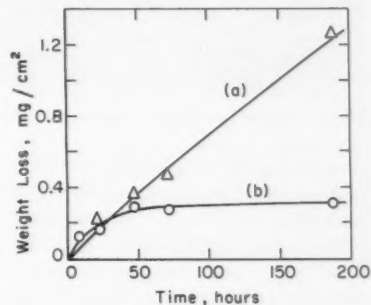
ULTRASONIC SIMULATION OF HIGH VELOCITY

THE DEVELOPMENT OF USEFUL ALLOYS MUST INCLUDE AN EVALUATION OF ALLOY PERFORMANCE UNDER VARIOUS ENVIRONMENTAL CONDITIONS. Accelerated laboratory tests, which simulate, the conditions to be encountered, are often used in such evaluations. The corrosion rates of different alloys in a sea-water environment are affected by the build up of a protective film on the specimens. This build-up, however, does not occur in some applications, such as in a desalination plant where high velocity flow may be desirable for efficient, economical operation. This flow is too rapid to allow accumulation of thick protective films. While testing the effects of alloy composition on the corrosion rate in salt water, L. J. Swartzendruber and L. H. Bennett of the Institute for Materials Research, in work partially supported by the Office of Saline Water, found that a 25 kHz ultrasonic generator could be used in the comparison of corrosion rates determined under moderate-to-high velocity conditions.¹ For laboratory development tests, this

technique may be preferred to the jet-impingement or rotating-disk methods because it requires less elaborate equipment and sample preparation.

Comparison studies were performed using two methods for determining the corrosion rate of foils of 67% Cu - 33% Ni in simulated sea-water. In the first study the samples were rotated in a stationary bath with baffles to promote turbulence. After rapid initial corrosion, which took place in the first 50 hours, a thick film was built up and the corrosion rate leveled off. In contrast, the method using stationary foils in an ultrasonic bath produced a corrosion rate which continued at an almost constant rate for 200 hours. The film condition on the samples after 200 hours in the ultrasonic bath was similar to the initial thin film noted on the rotating samples.

Because the ultrasonic bath does not allow thick protective films to adhere to the sample specimen, the initial corrosion rate may be observed for a longer period of time. The weight losses that occur in this



Weight loss as a function of time for two foils of 67% Cu-33% Ni at 70°C in bath of 3.5 weight percent NaCl under two different conditions: (a) with ultrasonic agitation at 25 kHz; (b) with sample rotating at 40 cm/s.

time are greater, making more accurate measurements of the initial corrosion rate possible. With these measurements investigators can more easily compare the effect of alloy composition changes on corrosion rates occurring under high flow rate conditions.

¹ For further details, see Swartzendruber, L. J. and Bennett, L. H., Use of ultrasonics in laboratory development tests of cupro-nickel alloys for desalination, *J. Desalination* **9**, No. 4, 387-389.

MOLE ADOPTED

AS INTERNATIONAL SYSTEM BASE UNIT

Representatives of 41 nations, serving on the General Conference of Weights and Measures (CGPM), recently voted to adopt the "mole" as a "base unit" of the International System of Units (SI). The mole, a measure of the quantity of matter, joins that special class of units that already includes mass, length, time, temperature, electric current, and luminous intensity.

Dr. Lewis M. Branscomb, Director of the National Bureau of Standards, U.S. Department of Commerce, headed the U.S. delegation to the October 4-9, 1971, meeting, the 14th since the Treaty of the Metre was signed in 1875. The legislative decisions of the CGPM generally follow recommendations from the CIPM, the International Committee of Weights and Measures—a panel of expert metrologists appointed by the CGPM. The detailed studies required in formulating the CIPM's recommendations are generally carried out by the Consultative Committees, which consist of highly specialized working metrologists. The CGPM also approves the budget and scientific activities of the International Bureau of Weights and Measures (BIPM).

The mole is defined as "the amount of substance of a system containing as many elementary entities as there are atoms in 0.012 kg of carbon-12." Its symbol is "mol". When the mole is used, the elementary entities must be specified and may be atoms, molecules, ions, electrons, or other particles, or other specified groups of such particles. This definition provides a way

of specifying the amount of substance without requiring a knowledge of Avogadro's number, viz. the actual number of atoms of ^{12}C in 12 grams of ^{12}C . This way of defining the mole is preferred because of our present inability to individually count very large numbers of particles with a degree of precision comparable to that with which we can compare the relative amounts of two samples, for example, by chemical methods.

Two of the derived units in the International System, namely pressure and conductance, were given additional names. The new short name for the SI unit of pressure, newton per square metre, is the pascal (symbol Pa), while that of conductance, the reciprocal ohm, is the siemens (symbol S). The pascal was already legal in many countries and its adoption at this time may lead to further abandonment of the bar. Similarly, the siemens has been in official use since 1935 by the International Electrotechnical Commission. After acceptance of these units, Dr. Branscomb urged the conference to put aside any further name changes in the SI units. Those nations which are involved in or are considering a change to the metric system will particularly value a period of stability in SI units while they are being evaluated for popular as well as scientific use, Dr. Branscomb said.

Other actions by the conference included adoption of the following definition: "Atomic International Time (TAI) is the time reference coordinate established by the International Bureau of the Hour (BIH)

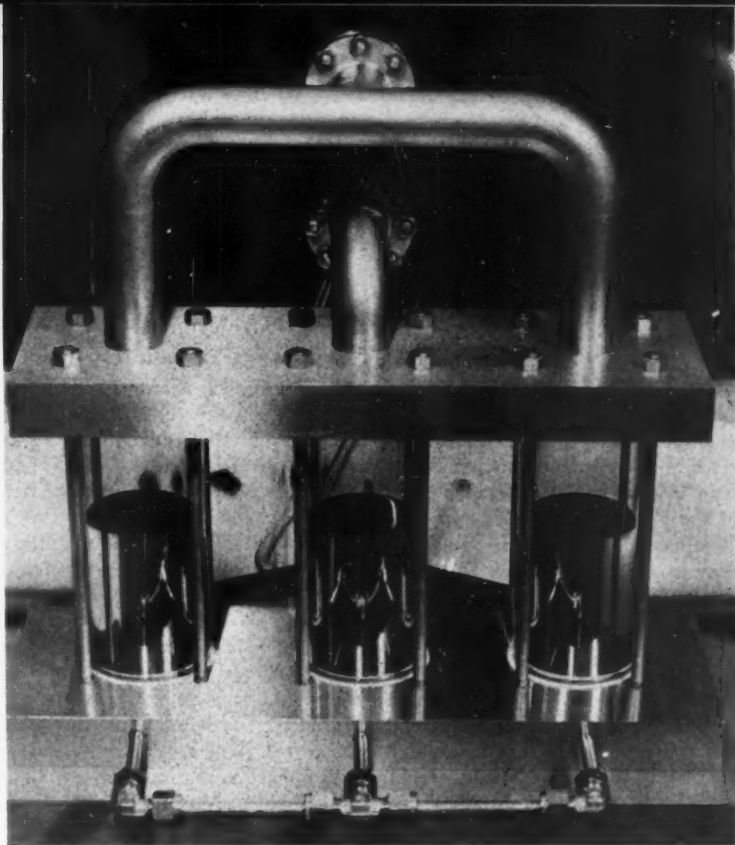
on the basis of readings of atomic clocks functioning in various laboratories in conformity with the definition of the second, which is the unit of time of the International System of units." Any instant may be defined on such a scale with an accuracy of the order of $1\ \mu\text{s}$ and world synchronizations are possible with this precision. Unfortunately, the definition of TAI as given above includes no prescription for BIH to follow in coordinating the various laboratories or synchronizing their clocks. This matter has received and continues to receive a great deal of attention, but is technically a very demanding problem. It is expected that such a prescription will be forthcoming in the future; in the meantime the CGPM noted the excellent work and leadership of BIH.

Budgetary measures proved to be one of the key issues on the conference agenda, particularly the question of using nonconvertible national currencies for the payment of dues. [In the past, payments have been made in gold francs.] It was finally agreed that a financial statement would be published to reveal the amount and effectiveness of all payments made in national currencies and the usefulness of such currencies to BIPM. The fraction of national currencies contributed by any one country was restricted to 22 percent of its total payment. Also, representatives agreed to provide for both a 9-percent annual cost of living increase and a 2.8-percent budget increase for program expansion. Growing at this rate the total budget for the International Committee on Weights

Mercury manometer developed at NBS in conjunction with an ultrasonic interferometer for automatic continuous measurements of pressure. The pascal has been adopted as a short name for the SI unit of pressure, newton per square metre.

and Measures will reach 4,670,000 gold francs (approximately \$1,560,000) by 1976. Another observation of some interest from the monetary standpoint was that BIPM has established its fund for general equipment at a level equal to 10 percent of total operating expenses.

Americans may take some pride in learning that the primary balance now used by BIPM for intercomparisons of kilogram standards was recently provided on loan by NBS. This loan not only fulfills a requirement for achieving international compatibility of U.S. mass standards, but has also built respect for both our technical excellence and our generosity.



CCST NEWS *Continued*

activities are available for those areas of computer applications most important to the Federal Government. The Center, working with appropriate mission-oriented agencies, will work to eliminate deterrents to effective computer utilization in such service areas as health care delivery, welfare and medical payments services, education, law enforcement, and mass transportation. The overall aim is to improve the quality and availability of service in these areas and to decrease the costs of such services through the use of automation technology.

The EXPLORATORY DEVELOPMENT program is oriented toward anticipating and resolving problems which will confront the computer customer in 3 to 5 years. The program will resolve problems of computer utilization

that unduly constrain the customer, will provide the technical foundations for standards activities, and will resolve problems which result in prohibitive costs to the customer or produce inequities in the computer services marketplace.

The SCIENTIFIC AND TECHNOLOGICAL ADVISORY SERVICES program is the mechanism by which CCST provides technical inputs to ADP policy formulation and assists Federal agencies in solving specific ADP problems. The Center's work under this program falls into five distinct categories: support to the formulation of ADP policies; computer technology assessment and forecasting; support to U.S. activities in international computer technology; support to other Federal agencies; and computer information services.

The COMPUTER SERVICES

program provides computer and related services to NBS and other agencies on a cost-reimbursable basis. The principal activity is the operation of the UNIVAC 1108 computer facility which supports NBS requirements for scientific and business data processing services.

SUMMARY

As indicated at the outset, this article is intended only to give a brief sketch of the current computer environment and CCST's reoriented technical program aimed at resolving the critical problems which characterize the environment. Future articles in this series will present the details of some of the Center's major program activities. A further source of information is Dr. Davis' testimony before the House Subcommittee on Science, Research and Development, on September 22, 1971.*

OPTICAL RADIATION NEWS

CONFERENCE ON RADIOMETRY AND PHOTOMETRY

A meeting of great potential significance for those working in the field of photometry and radiometry in the United States took place on October 28, 1971 at the National Bureau of Standards in Gaithersburg, Md. This was a "Conference on the Definition of Pressing Problems and Projected National Needs in Radiometry and Photometry." In attendance were representatives from 12 industrial companies, one military agency, one NBS Boulder representative, and 11 people from NBS Gaithersburg.

Because of the vitality and recent rapid growth in the electro-optics field, a need has arisen for a better communications channel among users of optical radiation standards as well as with NBS. While improved technical communication can have a tremendous impact in the field, other important benefits can result. Consensus, in a representative industrial group, for assignment of priorities to various standards and techniques will be of immediate benefit to NBS and to industry. In addition, an authoritative assessment of the consequences of the unavailability of specific new standards and techniques will assist both NBS and the Government as a whole in the assignment of more general priorities. With such assistance, NBS can play a more efficient and effective role in the development of new standards, the improvement of old standards, and the promotion of a better understanding of the uses and limitations of optical radiation standards and detectors in general. Toward

these ends the Conference attendees agreed to submit lists to NBS containing the needs of their respective companies with an emphasis on a statement of the impact for each listed need.

Consensus at this meeting thus developed around two central ideas. First, a permanent organization is required to facilitate the various kinds of communication described above on a modest but continuing basis. And second, the type of technical communication foreseen above will have to result in a series of topical meetings such as that described in the original Optical Radiation News section of the *NBS Technical News Bulletin*.¹

To these ends a second meeting was called for January 1972. Its chief purpose will be to review and organize the responses on needs and to lay out a plan for action. Consideration will be given to the proposal that these meetings assume their permanent organizational form as an activity of the American Technical Committee E-1.2 of the CIE, the Commission Internationale de l'Eclairage.

Broadened participation in future meetings is encouraged. Information can be obtained from Dr. Bruce Steiner, National Bureau of Standards, Washington, D.C. 20234.

UNCERTAINTY AND LUMINOUS INTENSITY

Each year NBS issues reports of calibration on 50-100 lamp standards of luminous intensity operated at the color temperature of CIE standard illuminant A (2856 K, IPTS 68).² In the hope of making these reports more useful to the

recipients, a document has been prepared describing the procedures and techniques NBS uses in calibrating these lamps. The following material is drawn from the uncertainty section of this document.*

In the measurement of a property of a material object, such as the luminous intensity of an incandescent lamp, an uncertainty statement is an estimate of the *possible* discrepancy between the reported value and the physical parameter this value represents; that is, an estimate of the possible error in the reported value. Such uncertainties are usually based on a statistical treatment of the random variations of the measurements and on theoretical deductions together with direct measurements of the possible sizes and types of biases that one recognizes may be present. Of course, any bias not recognized or not measured is not considered in determining the uncertainty. Therefore, the true error is never *known*. Its possible value is merely estimated with varying degrees of sophistication and assurance ranging from that resulting from a few measurements and an approximate theory to years of investigation and continued validation using an "exact" theory. No useful way has yet been devised to quantify the reliability of the uncertainty. It can be judged qualitatively only from the extent and sophistication of its characterization and the degree to which it has been subjected to continuing validation.

*Copies of the complete document will be included with every new calibration report issued or may be obtained by writing Mrs. V. I. Burns, NBS, Room 8312, Bldg. 220, Washington, D.C. 20234.

Inherent in an uncertainty statement is the concept that it is *unlikely* that subsequent determinations of the same invariant physical parameter for the same material object will deviate from the original determination by more than the stated uncertainty. Such subsequent determinations may be in the form of replications (identical theory, instrumentation and procedures), or complete redeterminations (totally different theory, instrumentation and procedures), or any combination of the two. The totality of the theory, instrumentation, and procedures which NBS uses in obtaining a given reported value and its uncertainty is designated the NBS process. Characteristic of a well-developed process is a complete and sophisticated investigation that led to its establishment. Characteristic of a well-run process is a continuing validation of the process parameters (precision, checks for possible biases, etc.) in the form of replications and periodic redeterminations. The greater the extent and completeness of the fundamental investigations and the higher the degree of redundancy in the continuing process, the greater the confidence that the discrepancy between the sought-after value and the value being reported is not larger than the assigned uncertainty.

The photometric chain, which is used by NBS in realizing and maintaining the illuminant A candela, is subject to a number of biases. These may be considered in terms of the three major steps used in the generation of the reported values:

(A) Platinum point realization. Specific sources of possible biases include: the effect of impurities on the freezing point of platinum, the quality of the blackbody cavity, and diffraction effects.

(B) Photometric transfer to illuminant A. Specific sources of

possible biases are the non-linearity and spectral response characteristics of the detectors.

(C) Substitution calibration of test lamps. Two distinct types of bias, constant and time dependent, are possible. If the operation of the working standard lamps does not duplicate in all essential respects the conditions under which their assigned values were derived, or if these working standards have changed, a constant bias will be introduced into all measurements. On the other hand, if the photometric apparatus is sensitive to variations in an uncontrolled parameter, for instance, environmental temperature or humidity, a time dependent (for example, day-to-day) bias will result.

The different biases will have varying effect on the uncertainty with respect to the three bases represented by (1) SI candela, (2) the world mean candela, and (3) the NBS candela. For example, biases in the NBS realization of the platinum blackbody will have a direct effect on the uncertainty with respect to the candela as maintained by NBS, and an indeterminate effect on the uncertainty with respect to the world mean. The last possibility arises because the various national standardizing laboratories have utilized similar equipment and techniques for realizing the primary standard of light, and thus may all have the same bias. Biases introduced during the transfer chain will have a direct effect on the uncertainty with respect to SI and world mean, but no effect on the uncertainty with respect to the unit as maintained by NBS. Only the biases of the substitution calibration will affect the uncertainty of a reported value with respect to NBS. The user of a lamp standard of luminous intensity will usually wish to know his uncertainty with respect to one or more of

these bases. The remainder of this section presents data and procedures currently used to assign uncertainties to the illuminant A luminous intensity calibrations.

Three biases will affect the uncertainty of a reported value with respect to the candela as maintained by NBS. These are: (1) constant biases of the substitution calibration of the test lamps, (2) time dependent biases of the substitution calibration and, (3) random variation of the measurements. No detailed investigation has yet been made of the possible constant biases of the substitution calibration. The uncertainty due to the other two biases was determined in 1970 from a study of 124 measurements on 36, 500-watt lamps and 80 measurements on 20, 100-watt lamps. These data indicate that time dependent biases are present in the process and usually amount to 0.2-0.3 percent, though a few as large as 1 percent have been observed. These bias percentages include short-term lamp instabilities. Occasionally, for example, changes of 0.5 percent have been observed in merely turning a lamp off and then on again. Assuming that these time dependent biases are due to the random variation of an uncontrolled parameter, a statistical analysis has been made of the measurements. A pooled estimate of the standard deviation of a single measurement has been calculated to be 0.3 percent. In assigning a value to the uncertainty, an allowance of 1.0 percent is made for the time dependent bias in the data and an additional allowance of 0.5 percent is made for the random variation in the measurements (three times the standard deviation of the mean of three measurements). The uncertainty assigned to a reported value with respect to the candela as maintained by NBS is the sum of these two components or 1.5 percent.

The most recent international intercomparison of the candela at the

color temperature of CIE illuminant A, showed a range of 1.7 percent among the eight participating national standardizing laboratories including NBS.³ Adding the calibration uncertainty of transferring the NBS candela to a test lamp (1.5%) to one-half this range (0.85%) yields our current uncertainty for a reported value of 2.3 percent with respect to the world mean.

The uncertainty of a reported value with respect to the SI candela will be subject to several sources of bias in addition to those discussed above. Although extensive investigations of these additional sources of bias have not been made, some relevant information exists on which to base an uncertainty. The same intercomparison referred to earlier³ showed that the candela at the color temperature of CIE illuminant A, as realized in the national standardizing laboratories of the world, was inconsistent with the candela realized at the color temperature of freezing platinum by as much as 3.5 percent.⁴ Also, recent theoretical work has indicated that previous realizations of the platinum point blackbody may have been in error by as much as 1.5 percent.⁵ Thus, in our current process there are six individual biases or sources of bias relative to the SI candela for which uncertainties have been assigned. These, together with the uncertainties associated with them, are listed below:

Biases	Assigned Uncertainty
I. Substitution Calibration	
A. Time dependent bias	1.0%
B. Constant bias	0.0
C. Random variation	0.5
II. Transfer Chain	
A. International inter-comparisons at 2856 K (1/2 range)	0.85
B. International inter-comparisons; inconsistency in realizing the candela at the platinum point and 2856 K	3.5
III. Platinum Point Calibration	1.5

It is unlikely that all these individual uncertainties would have the same sign resulting in a total uncertainty of 7.3 percent. Therefore a combination in quadrature (square root of the sum of the squares) resulting in 4.1 percent is considered to give the uncertainty of a reported value relative to the SI candela.

Recently a program was established at NBS for developing improved luminous intensity standards and methods of transfer and for more thoroughly characterizing biases and uncertainties. Results of this work will be published as they become available.

A RADIOMETRIC BIBLIOGRAPHY

In hopes of easing the burden of "keeping up in radiometry," a radiometric bibliography is being compiled and will be included as a section of the Optical Radiation News. The bibliography is motivated by the diversity of journals that publish papers in the field.

Radiometry is the science concerned with determining the power or related quantities carried by fields of electromagnetic radiation (radiance, irradiance, photon number and number density, luminance, illuminance, etc.). The area of pure and applied science which is basic to radiometry is electromagnetism (both classical and quantum). The interaction of electromagnetic radiation with matter is also important, as are portions of the quantum theory of atoms, molecules, solid state, and thermal physics. Electromagnetism is an extremely complex subject, and two separate scientific disciplines, which are based upon the simplifying approximation that electromagnetic radiation propagates along rays, have been developed: geometrical optics and radiative heat transfer. Much of radiometry is based upon these two disciplines. The emphasis in geometrical optics is upon determining the trajectory

of rays through (complicated) optical systems, while the emphasis in radiative heat transfer is on determining the net power gain or loss of surfaces and volumes that are exchanging energy by the emission, reflection, transmission, and absorption of electromagnetic radiation. To "keep up" in radiometry one must be aware of the pertinent work being published in the fields of radiation heat transfer, geometrical optics, electromagnetic theory, quantum electrodynamics, thermal physics, solid state physics, atomic physics, and molecular physics. Furthermore, much radiometric work is carried out in such areas as aerospace technology, astrophysics, meteorology, and thermometry. As a result, radiometric papers are scattered throughout a wide variety of journals and special publications, making it a time-consuming chore for any one person to cover.

Our plan is to enlist a number of volunteers, so that any one individual is required to cover only one or two journals. The criteria for selecting a paper for listing in the bibliography are:

TABLE 1. JOURNALS CURRENTLY BEING COVERED FOR RADIOMETRIC BIBLIOGRAPHY

Journal	Individual Responsible
AIAA Journal	J. C. Richmond
Applied Optics	R. D. Saunders, Jr.
Astrophys. J.	A. R. Schaefer
Australian J. Phys.	A. T. Hattenburg
Canadian J. Phys.	D. A. McSparron
Indian J. Phys.	K. Mohan
High Temperature	J. B. Shumaker
Int. J. of Heat and Mass Transfer	J. J. Hsia
J. American Ceramic Soc.	R. D. Lee
J. Applied Phys.	E. F. Zalewski
J. of Heat Transfer (Trans. ASME)	J. J. Hsia
J. of Quant. Spec. and Radiative Transfer	E. F. Zalewski
J. Optical Soc. America	H. J. Kostkowski
Metrologia	D. A. McSparron
Optics and Spectroscopy	W. H. Venable, Jr.
Optik	W. B. Fussell
Phys. Rev.	B. W. Steiner
Phys. Rev. Letters	B. W. Steiner
Physica	W. R. Waters
Proc. Roy. Soc.	A. R. Schaefer
Quart. J. Roy. Meteorological Soc.	K. L. Ecklerle
Rev. Sci. Inst.	C. R. Yokley

- (1) "Measurement papers" must be concerned primarily with a radiometric property and not the wavelength or atomic or molecular structure, i.e., spectroscopy.
- (2) Papers describing calculations must be directed at techniques or results of a general nature. Papers emphasizing specific results will be included only if they concern objects of radiometric interest, such as blackbodies or integrating spheres.
- (3) Theoretical papers must be concerned primarily with the

properties of electromagnetic radiation or upon those aspects of the interaction of electromagnetic radiation with matter which are of interest in radiometry, such as detector mechanisms.

The starting date for our coverage is January 1972. Only the title of the paper and the journal reference will be given. Table I lists the journals presently included and the individuals that have volunteered to follow them. We welcome additional volunteers to cover other journals, including foreign language journals. In the latter case, we

request that the title be translated into English by the volunteer.

Anyone interested in participating in this endeavor should write to Jon Geist, Room A223, Metrology, National Bureau of Standards, Washington, D.C. 20234, giving your name, address, and the journal that you are willing to follow.

¹ Optical Radiation News, Nat. Bur. Stand. (U.S.), Tech. News Bull. 55, No. 10, 256-257 (1971).

² Color Temperature, Luminous Efficacy and the International Practical Temperature Scale of 1958, Nat. Bur. Stand. (U.S.), Tech. News Bull. 54, No. 9, 206-207 (1970).

³ Comité Consultatif de Photométrie, 5^e Session, p. 84 (1962).

⁴ Comité Consultatif de Photométrie, 6^e Session, Annexe 3, p. P28 (1965).

⁵ Ibid., Annexe 1, p. P17.

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Technical News Bulletin, Annual subscription: Domestic, \$3; foreign, \$4. Single copy price, 30 cents. Available on a 1-, 2-, or 3-year subscription basis. SD Catalog No. C13.13.56.

Journal of Research of the National Bureau of Standards

Section A. Physics and Chemistry. Issued six times a year. Annual subscription: Domestic, \$9.50; foreign, \$11.75. Single copy price varies. SD Catalog No. C13.22/sec.A:74.

Section B. Mathematical Sciences. Issued quarterly. Annual subscription: Domestic, \$5; foreign, \$6.25. Single copy, \$1.25. SD Catalog No. C13.22/sec.B:74.

Section C. Engineering and Instrumentation. Issued quarterly. Annual subscription: Domestic, \$5; foreign, \$6.25. Single copy, \$1.25. SD Catalog No. C13.22/sec.C:74.

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Liquefied Natural Gas. A literature survey issued quarterly. Annual subscription: \$15.

Superconducting Devices and Materials. A literature survey issued quarterly. Annual subscription: \$15.

Send subscription orders and remittances to the Cryogenic Data Center, Room 2022, Cryogenics Building, National Bureau of Standards, Boulder, Colo. 80302.

Electromagnetic Metrology Current Awareness Service (Abstracts of Selected Articles on Measurement Techniques and Standards of Electromagnetic Quantities from D-C to Millimeter-Wave Frequencies). Issued monthly. Annual subscription: \$100 (Special rates for multi-subscriptions). Send subscription order and remittance to the Electromagnetic Metrology Information Center, Electromagnetics Division, National Bureau of Standards, Boulder, Colo. 80302.

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